REMARKS

Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-48 were pending in the application. Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-48 are rejected under 35 U.S.C. § 103 (a) as being deemed unpatentable over U.S. Patent No. 5,699,440 (Carmeli) in view of Applicants' Admitted Prior Art and U.S. Patent No. 6,052,124 (Stein *et al.*). Of the Claims, Claims 1, 6, 11, 16, 21, and 46 are independent Claims. Claims 25-35 have been amended to correct dependency. Claim 49 is newly added. The rejections are respectfully traversed and reconsideration is requested.

Regarding Claim Objections

The numbering of Claim 49 is objected to because there is no claim 48. Claim 49 has been renumbered 48. Removal of the objection is respectfully requested.

Regarding rejection under 35 U.S.C. 103(a)

Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-48 are rejected under 35 U.S.C. § 103 (a) as being deemed unpatentable over U.S. Patent No. 5,699,440 (Carmeli) in view of Applicants' Admitted Prior Art and U.S. Patent No. 6,052,124 (Stein *et al.*).

To establish a prima facie case for obviousness under 35 U.S.C. § 103 (a), (1) there must be some suggestion or motivation to combine reference teachings. (2) There must be a reasonable expectation of success. (3) The references when combined must teach or suggest all the claim limitations. For the reasons discussed below, it is respectfully submitted that the Office has not established a prima facie case under 35 U.S.C. § 103 (a) for claims 1, 4-6, 9-11, 14-16, 19-21 and 25-48, and that therefore, claims 1, 4-6, 9-11, 14-16, 19-21 and 25-48 are allowable.

Prior art methods for calibration, including the calibration method discussed in cited prior art Stein and in the background section of the present invention require some form of image feature, or registration between multiple images in order to extract camera parameters. In contrast, the Applicants claim a simple method for calibrating a camera without the use of specialized patterns or registration as required by the prior art. All that is required is a single blank piece of paper.

The applicants' claimed invention is directed to the use of camera defects that result in pixel intensity drop off in a digitized image to recover intrinsic parameters (e.g. focal length) of a camera. A blank piece of paper with uniform illumination is digitized. In a camera with no defects, all pixels in the digitized image would have the same intensity. However, due to camera defects, there is a pixel intensity drop off in the digitized image. This pixel intensity drop off is based on geometric and optical defects of the camera. The pixel intensity drop off is caused by a vignetting effect (a reduction in illumination of image points at the edge of the image (see equation 14 in the applicants' specification)) which is geometric in nature (based on partial obstruction of light by the lens stop) and an off-axis illumination effect (illumination of the image point varies across the field of view in proportion to the fourth power of the cosine of the angle between the light ray and the optical path (see equation 5 in the applicants' specification)) which is optical in nature. The intensity of a pixel (image point) in the digitized image is dependent on a combination of these effects (geometric and optical).

The intrinsic parameters (e.g. focal length) of the camera are recovered using substantially only the pixel intensity drop off in the digitized image. One advantage of the Applicants' claimed calibration technique is that no special patterns are required. Thus, the Applicants' claimed technique recovers a camera intrinsic parameter from a single image of a blank textureless surface.

Cited prior art Carmeli discusses an electro-optical system that includes a calibrated camera 12 (Fig. 1a/1b) and a computer 17 that includes memory storing a database. Carmeli discusses a uniform light function applied through the complete area of a reticle and analyzing the fall off of the output signal at the edges and corners to evaluate the effect of vignetting. (See Col. 11, lines 10-16; Figs 10a and 10b.) Carmeli only discusses the use of uniform illumination to evaluate vignetting. Other parameters of the electro-optical system are evaluated using other techniques. For example, grey level linearity of the electro-optical system is calculated through the use of a reticle having a plurality of different grey regions. (See Figs. 9a/9b.) Also, the test for distortion described in conjunction with Fig. 11 requires a reticle having a plurality of input points. Thus, Carmeli does not teach or suggest determining pixel intensity drop off caused by an off-axis pixel projection effect from a digitized "image of a blank textureless surface having a uniform illumination".

Cited prior art Carmeli merely discusses measuring the electro-optical performance representative of illumination uniformity based on evaluating the effect of vignetting on an output signal. (See Col 5, lines 52-57; Col. 6, lines 48-50; Col. 9, lines 52-61; Col. 11, line 16 and Col. 14, lines 7-18.) The intensity drop off measurement is the end result. There is no use of that measurement to recover (extract) another intrinsic parameter of the camera such as focal length. Carmeli does not discuss determining pixel intensity drop off caused by off-axis illumination. Carmeli merely discusses other tests that use test patterns with strong edges and contrast. For example, the grey level uniformity test uses a test pattern shown in Fig. 9a/9b that uses contrast and the geometric distortion test uses the test pattern shown in Fig. 11. Instead of relying on edges and contrast, the applicants' claimed calibration technique uses substantially only the pixel intensity drop off (intensity distribution) in the digitized image of a blank textureless surface having uniform illumination.

Carmeli does not use the result of the measurement of illumination uniformity to recover intrinsic parameters of the camera. Carmeli does not even discuss camera calibration or aspect ratio. In contrast, the camera is already calibrated (See Fig. 1b, calibrated camera 12.) Carmeli merely discusses storing focal length of a pre-calibrated lens in a database. (See Col 8, lines 40-44.) As is well-known to those skilled in the art, a camera typically consists of a lightproof chamber with an aperture fitted with a lens and a shutter through which the image of an object is projected onto a surface for recording. However, Carmeli apparently uses the term "camera" to refer to the imaging function of an electro-optical system that includes a target, light source, and lens in addition to a camera. As discussed in col. 8, lines 30-35, the camera specifications only include the parameters for the imager for generating the image, for example, the number of pixels, type of imager and pixel size. The lens is shown separate from the component labeled "camera". (See Fig. 1A.) Standard calibrated electro-optical components are substituted in the electro-optical system and electro-optical performance of the substituted component is computed. The parameters of the calibrated electro-optical components are known and stored in a database. For example, the focal length of a pre-calibrated lens is stored. Figs. 3 to 15a show different reticles for use with a target to evaluate different performance parameters of the lens. Carmeli does not discuss calibration of the electro-optical system or of any of the components in the electro-optical system.

Stein does recover intrinsic parameters of the camera. However, Stein merely uses specialized patterns to recover these parameters. Therefore, Stein does not teach or suggest the Applicants' claimed "recovers an intrinsic parameter of the camera other than pixel intensity drop off based on substantially only the determined pixel intensity drop off". There is no teaching or suggestion in Stein to use other than well-known methods for recovering intrinsic parameters of a camera. There is no teaching or suggestion in Carmeli to recover intrinsic parameters of a camera. In contrast, these parameters are already known and stored in a database.

There is no suggestion or motivation to combine Carmeli, Stein and Applicants' admitted prior art and the references when combined do not teach or suggest all the claim limitations. The combination of Carmeli, Applicants' admitted prior art and Stein merely teaches use of specialized patterns to obtain intrinsic parameters, storing the obtained parameters into a database and then using the parameters stored in the database to test the performance of the camera.

The foregoing patentable distinctions are recited in base claims 1 and 6 with the language or similar language:

> "recovers an intrinsic parameter of the camera other than pixel intensity drop off based on substantially only the determined pixel intensity drop off"

Independent claim 11 recites a like distinction in terms of a computer system and thus similarly patentably distinguishes over the prior art. Independent claims 16 and 21 recite a like distinction in terms of an apparatus. Independent Claim 46 includes like limitations distinguishing the cited art.

Claims 4-5 and 9-10 are dependent on base claims 1 and 6 respectively and thus include this limitation over the prior art. Claims dependent on claims 11, 16 and 21 include this limitation over the prior art. Claims 47 and 48 are dependent on base claim 46 and thus follow.

Dependent claims 4, 9, 14 and 19 recite that "the step of computing is dependent on a camera tilt effect" that is neither taught nor suggested by Carmeli. The align step discussed by Carmeli does not teach or suggest a camera tilt effect. In contrast, the align step aligns an image so as to provide sharp focus and correct for optical magnification so that the target is correctly

aligned to the lens and camera. An image is formed and is aligned so as to produce sharp focus and correct for optical magnification so that the target is correctly aligned to the lens and camera. (See Col. 2, lines 52-55.)

Dependent claims 5, 10, 15, 20 and 25 recite "computing the parameters of a model by minimizing the difference between the digitized image and the model that is neither taught nor suggested by Carmeli. Carmeli merely stores parameters in a database and uses the stored parameters to form and align an image. (See Col. 6, lines 39-50.)

Support for new claim 49 is found at least on Page 6, lines 23-25, Page 11, lines 10-12, and Page 12, lines 15-17 in the applicants' specification as originally filed. No new matter is introduced. Acceptance is respectfully requested.

Accordingly, the present invention as now claimed is not believed to be anticipated by or made obvious from the cited art or any of the prior art. Removal of the rejections under 35 U.S.C. §103 (a) and acceptance of Claims 1, 4-6, 9-11, 14-16, 19-21 and 25-49 is respectively requested.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

HAMILTON, BROOK, SMITH & REYNOLDS, P.C.

By Caroline M Fleming

Caroline M. Fleming
Registration No. 45,566
Telephone: (978) 341-0036
Facsimile: (978) 341-0136

Concord, MA 01742-9133
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